Cardiovascular Changes after Bilateral Upper Dorsal Sympathectomy

Short- and Long-term Effects

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The effect of bilateral upper dorsal sympathectomy (UDS) on cardiac function was investigated in two groups of young healthy patients who underwent bilateral excision of T2 and T3 ganglia for palmar hyperhidrosis. In ten patients echocardiography of left ventricular function (LVF) was performed before operation and 2 weeks after operation. Electrocardiograms (ECG) were done before operation, during operation immediately after sectioning each sympathetic chain, and at 2 weeks after operation. The mean pulse rate decreased significantly in patients after they underwent bilateral UDS. There were no clinical arrhythmias or changes in LVF in any patient. Submaximal exercise testing and ECG tracings done at rest and after effort were obtained for 29 patients before undergoing bilateral UDS, 30 days after operation, and 1–3 more times within a 2-year postoperative period. Pulse rates taken at rest and after effort were significantly lower than those taken after operation, and the blood pressure response to exercise was blunted. ECG tracings showed a significant change in the electrical frontal plane axis and shortening of the QTc interval. These changes were evident 30 days after operation and persisted for 2 years. In conclusion, bilateral UDS has no overt arrhythmogenic effect in the young, healthy heart and its beta-blocker–like effect persists for at least 2 years.

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BILATERAL UPPER DORSAL SYMPATHECTOMY (UDS) is an accepted practice in the treatment of primary hyperhidrosis (PHH). Bilateral UDS involves the removal of T2 and T3 ganglia.[1] Since part of the sympathetic fibers to the heart traverse these two ganglia, we examined the possible early and late effects of this partial sympathetic denervation of the heart in patients who underwent bilateral UDS for PHH.

Materials and Methods

Thirty-nine patients underwent bilateral UDS for primary PHH, 24 males and 15 females aged 17–34 years (mean ± SD: 21 ± 3). All patients were healthy and had no known cardiac disorders. The operation was performed by two teams using a bilateral supraclavicular approach.[2] Both teams began the operation simultaneously, but the sympathetic chains were sectioned sequentially with approximately 10–15 minutes elapsing between the division of each side. Frozen-section confirmation of removal of the ganglia (T2 and T3) was obtained in all patients. All patients had dry hands immediately after operation and 27 patients had dry hands throughout the follow-up period.

A short-term study was performed in 10 patients (group A), and a long-term study was performed in 29 patients (group B). Before operation all patients from both groups gave a detailed medical history and had a physical examination that included a 12-lead electrocardiogram (ECG) and a near-maximal exercise test (80–85% of maximal predicted pulse rate) using an upright bicycle ergometer.[3]

Group A (N = 10) had a preoperative M-mode echocardiogram to evaluate left atrial and left ventricular dimension (end-diastolic and end-systolic) and left ventricular contraction (fractional shortening). Global and segmental ventricular function were evaluated by two-dimensional echocardiography in the parasternal long- and short-axis views and the apical four-chamber view.

The exercise tests and the echocardiograms were repeated in group A 12–16 days after operation. In addition, all these patients had ECG tracings performed before sectioning the sympathetic chains, after the removal of T2 and T3 ganglia on the first side, after removal of T2 and T3 ganglia on the other side, and after skin closure. In

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TABLE 1. *The Effect of UDS on the Pulse Rate*

Side Operated On	No. of Patients	Preoperative PR*	Postoperative PR*	p Value
Right	5	87 ± 4	73 ± 3	<0.05
Left	5	84 ± 4	81 ± 5	NS
Right and left	10	86 ± 3	75 ± 2	<0.05

* Pulse rate (PR), results presented as mean ± SEM.

five patients the left-sided sympathectomy was performed first, and in the other five patients the right-sided sympathectomy was done first. No patients received cardioactive drugs at any time except for routine anesthetics.

Group B (N = 29) was re-examined 1 month after operation, and then at different intervals up to 2 years after operation. The postoperative examination in this group included an ECG done at rest and after effort and submaximal exercise testing.

QT measurements. QT interval was measured in milliseconds and corrected for pulse rate by Bazzett's formula: $QT_c = QT/\sqrt{R\text{-}R}$ (where R-R is the R-R interval in seconds on ECG).

Statistics. The data are presented as mean ± SEM. Results were compared by Student's t-test.

Results

Group A

The effect of UDS on the exercise test. All patients successfully completed a submaximal exercise test before operation. In contrast, dyspnea and fatigue caused early termination of the exercise test in three patients after operation (two females and one male). The pulse rate response to exercise was decreased in seven patients by 6–12% (mean: 8%) after operation, at similar exercise load. No alterations in echocardiograms of left ventricular function (LVF) were found after operation.

The effect of UDS on the pulse rate and QTc. As seen in Table 1, the pulse rate was decreased after right-sided UDS in five patients, from a mean value of 87 ± 4 beats/min to 73 ± 3 beats/min ($p < 0.05$). In two patients, the pulse rate was increased after having left-sided UDS from 60 to 89 beats/min and 81 to 100 beats/min, respectively, and later decreased after having right-sided UDS. In all ten patients pulse rate taken at rest was decreased after having bilateral UDS from a mean preoperative rate of 86 ± 4 beats/min to 75 ± 2 beats/min ($p < 0.05$) (Table 1).

In two of the patients who had right-sided UDS first, the QTc was prolonged by 9 and 10% and returned to the control level after bilateral UDS was completed. The QTc was unchanged in the other eight patients.

Group B

The effects of UDS on the exercise test. Before operation the mean physical working capacity for the 29 patients was 112 ± 7 watts (135 ± 6 watts for 18 males and 75 ± 6 watts for 11 females), and all patients completed the test. At 30 days after operation, nine of 29 patients did not complete the test because of weakness in the legs, dyspnea, dizziness, or general fatigue that occurred before submaximal pulse rate and blood pressure values were attained.

Changes in pulse rate, systolic and diastolic blood pressure, and pulse pressure before and after operation that occurred at rest, after 50 watts of effort, and after submaximal effort are shown in Table 2. These results were obtained from all 29 patients 30 days after operation.

There was a significant decrease in the mean pulse rate and a significant decrease in the mean systolic pressure, which was more pronounced at rest and at 50 watts than at submaximal effort. The decrease in mean diastolic pressure was less after operation than before operation, but the difference was not significant, except at submaximal effort. Pulse pressure was significantly decreased after operation under all conditions.

As seen in Table 2, the difference in pulse rate between that taken at submaximal exercise and the resting pulse rate was 99 ± 3 beats/min before operation and 80 ± 4 beats/min after operation ($p < 0.05$). The increase in systolic blood pressure was 41 ± 2 mm Hg before operation

TABLE 2. *Pulse Rate and Blood Pressure Changes before and 30 Days after Bilateral UDS**

	At rest			50 Watts of Effort			Submaximal Effort		
	Before Operation	After Operation	p Value	Before Operation	After Operation	p Value	Before Operation	After operation	p Value
Pulse rate (beats/min)	74.5 ± 2	62 ± 2	<0.0001	126 ± 4	100 ± 3	<0.001	174 ± 1	143 ± 4	<0.001
Systolic blood pressure (mm Hg)	121 ± 1	112 ± 2	<0.0001	140 ± 3	126 ± 3	<0.001	162 ± 4	152 ± 5	<0.08 (NS)
Diastolic blood pressure (mm Hg)	78 ± 1	74 ± 2	<0.09 (NS)	68 ± 4	71 ± 2	NS	36 ± 6	59 ± 4	<0.05
Pulse pressure (mm Hg)	43 ± 2	38 ± 1	<0.05	73 ± 5	55 ± 3	<0.001	126 ± 7	93 ± 7	<0.001

* N = 29, results given as mean ± SEM.

and 40 ± 5 mm Hg after operation (NS). The decrease in diastolic blood pressure from the resting value to the true value at termination of submaximal effort was 42 ± 6 mm Hg before operation and 15 ± 5 mm Hg after operation ($p < 0.05$). The pulse pressure difference between submaximal exercise values and resting values was 82 ± 7 mm Hg before operation and 65 ± 5 mm Hg after operation ($p < 0.05$).

The effects on the ECG tracing. All ECG tracings taken at rest were normal before operation. After operation the mean manifest electrical QRS axis in the frontal plane and the T-wave amplitude in the precordial leads were unchanged. The QTc however changed from 399 ± 4 ms to 389 ± 4.3 ms after operation ($p < 0.05$). Interestingly, blunted T-waves were noted in the ECG tracings in 12 of 29 patients after operation. The PR interval and the width and amplitude of the QRS complexes were essentially unchanged.

All preoperative ECG tracings taken at maximal effort were normal. There were no significant differences in ECG tracings in preoperative effort and postoperative effort except for the above-mentioned differences in pulse rate (Table 1). Only one patient in the postoperative ECG had supraventricular extrasystoles that appeared during the recovery period from exercise.

The results of all tests performed remained unchanged in all patients during the 2-year follow-up period and no new arrhythmias appeared during this time.

Discussion

Although bilateral UDS is an accepted practice in the treatment of primary PHH most studies of UDS for PHH mention surgical results and complications.[1,2] However, few studies refer to the cardiac effects of this procedure, despite the fact that the T2 and T3 ganglia that are removed are in the direct pathway of the sympathetic innervation of the heart. In fact, surgical ablation of these ganglia is done during some procedures for various arrhythmias.[4–8]

Several authors have described the cardiac effects of unilateral or bilateral stellectomy and high thoracic sympathectomy or blockade in experimental animals and in humans.[4,8] Most of this work is concerned with the arrhythmogenic potential of these procedures and with the different effects of removal of the right and left ganglia.[9–13] Austoni et al.[11,12] showed that right and left stellectomy produce opposite effects on cardiac arrhythmias in experimental animals and in humans. Right stellectomy caused exercise-induced arrhythmias in 18% of humans and 86% of dogs. The QT interval was prolonged in 23% of humans.[11] Left stellectomy exerts a suppressing effect on ventricular arrhythmias but does not affect cardiac performance in dogs.[6,10,13]

In UDS only a portion of the sympathetic innervation of the heart is ablated, as only T2 and T3 ganglia are removed and the entire stellate ganglion is spared. We demonstrated in this study that there were clearcut short-term and long-term hemodynamic effects as well as ECG changes.

The QTc shortening in our patients resembles the effect of left-sided stellectomy.[4–6] Conversely, the transient increase in the QT interval after right-sided UDS in two patients in group A is in accordance with the prolongation of the QT interval noted in 23% of patients with right-sided stellectomy. Overall, the QT changes in our study were small and unlikely to be of any clinical significance.

The effect of UDS on the ECG and on the exercise test resembles the effects of β-adrenoceptor blockers.[14] At rest, there was a significant decrease in the pulse rate, which was probably caused by the decreased sympathetic innervation. Two patients in group A had a transient increase in the pulse rate after having left-sided UDS that was reversed after resection of the contralateral chain. This can be explained by a transient increase in sympathetic activity through the nerves that remained intact. In accordance with the findings, the control of pulse rate in dogs is mediated mainly by the right stellate ganglion, whereas the afferent limb of most cardiocardiac sympathetic reflexes seem to be prefentically distributed through nerves of the left side.[13,15] The weakness, dizziness, and dyspnea that occurred in some patients during postoperative exercise testing may have resulted from a mechanism similar to that of the impairment of exercise conditioning by propranolol.[16,17] This mechanism may also explain the attenuation of the pulse rate response to exercise despite deconditioning of the patients after bed rest.

There is a possibility that the dyspnea and attenuated exercise performance is due, at least in part, to pulmonary factors. Previously, we demonstrated some loss of lung volume and a decrease in maximal expiratory flow rates after bilateral UDS for primary PHH.[18,19] These abnormalities were probably related to the sympathetic denervation of the lung, but unlike the cardiovascular effects noted in the current study, these effects were transient. In patients examined 6 months after operation almost all pulmonary function test results had returned to normal.[18] Since the cardiovascular changes observed in our study lasted throughout the 2-year follow-up period, it appears that there are independent long-term cardiovascular effects of the sympathetic denervation. LVF at rest is not impaired as evidenced by the echocardiographic evaluations and, thus, overtly impaired ventricular contractibility does not play a role in the development of fatigue in these patients.

Therefore, the observed effects on the pulse rate, QTc, and near-maximal exercise test in patients who had bilateral UDS are probably due to decreased cardiac sympathetic tone that resembles the effect of β-adrenoceptor blocking agents. If this effect is long lasting, these patients may show an exaggerated reaction to beta-blockers administered after operation. Long-term observations of patients who had bilateral UDS would help to prove or disprove this hypothesis.

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